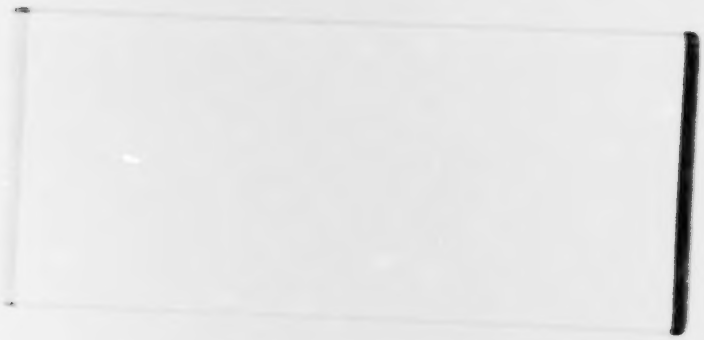


ENVIRONMENT
NEW BRUNSWICK

ENVIRONNEMENT
NOUVEAU-BRUNSWICK

CASIER POSTAL / P.O. BOX 6000, FREDERICTON, N.B., CANADA E3B 5H1

Technical Report Number T-8504

An Environmental Survey of Greenhill Lake, 1985

Environmental Services Branch

New Brunswick Department of Municipal Affairs and Environment

Fredericton, N. B.

December 1985

Summary

In response to reports of deteriorating water quality in Greenhill Lake, York County, New Brunswick and inquiries from cottage owners regarding control measures, Environment New Brunswick (now the New Brunswick Department of Municipal Affairs and Environment) staff surveyed the lake in 1985. Results indicated that high concentrations of phosphorus were present resulting in algal blooms which seriously impaired fisheries and recreational quality. The primary source of the problem was determined to be piggery waste which was discharged to a stream flowing to the lake.

The waste is now controlled and conditions in the lake should improve but the time required to reach acceptable conditions is uncertain. For the short term, it is recommended that algae be chemically controlled to temporarily improve recreational values. At the same time phosphorus movement and cycling should be studied to determine if measures to accelerate lake recovery are needed and, if so, which would be most effective.

AN ENVIRONMENTAL SURVEY OF GREENHILL LAKE, 1985

Background

Greenhill Lake, Bright Parish, York County, New Brunswick has a surface area of 20 hectares (49 acres) a maximum depth of 7.7 meters (25 feet) and an average depth of 3.1 meters (10 feet). Total volume is 620,000 cubic meters (495 acre feet) and the flushing rate is 5.1 times per year. Surface water is fed to the lake by a small stream which enters at the northwest corner. The outlet at the east end drains to the Keswick River via McKiel Brook.

The south shore is developed with approximately 30 cottages and five year-round residences. A United Baptist Church campground is located on the northeast side. The remainder of the lake is primarily surrounded by woodlands.

In 1983, cottage owners approached Environment New Brunswick (now the New Brunswick Department of Municipal Affairs and Environment) concerning ways to control heavy algal blooms which were seriously degrading the recreational quality of the lake. In fact, conditions had deteriorated to the point that a swimming pool was constructed at the church camp because visibility in the water was so limited that the beach was unsafe for swimming. Analysis of water samples and field data collected on August 3, 1983confirmed that the problem was indeed serious.

Initial impressions were that nutrients contained in natural runoff and in sewage from the cottages were causing the blooms. It was felt that little could be done in the short term to control the nutrient sources and that chemical control of algae was the best alternative available. On July 18, 1985 the lake was treated with an algaecide.

The Survey and Results

A water quality survey was conducted in the same year and included four general water quality stations and 14 inshore stations for measurement of bacteria levels (**Fig. 1**). Water chemistry samples were taken at the surface and at one half the distance to the bottom. Light penetration was measured with a Secchi disk and chlorophyll *a* samples were collected at the surface and at the Secchi depth. In addition, dissolved oxygen and temperature were measured at the surface and at depth intervals of one meter. Sampling took place approximately every two weeks from June through August and one series of samples was taken in late September.

While numerous parameters were measured, only those pertinent to the problem will be discussed here. Phosphorous, chlorophyll *a* and Secchi disk are the main indicators of algal production. Phosphorous is the nutrient which normally has the greatest effect on plant growth in a lake. The maximum acceptable total phosphorus concentration is considered to be 0.025 mg/l. Greater amounts indicate a high potential for algal growth. Chlorophyll *a* is a measure of the green pigments found in plants and, therefore, indicates the amount of algae present. Concentrations of 10-100 mg/m^3 reflect heavy growth typical of eutrophic (nutrient enriched) lakes. The Secchi disk reading is a measure of sunlight penetration into the water and declines as the algal density increases.

Total phosphorus concentrations in Greenhill Lake were consistently above 0.025 mg/l. Values at the inlet, Station 1, were greater than those measured at in the other parts of the lake **(fig. 2)**.

Chlorophyll a was generally in the 10-100 mg/m^3 range (Fig. 3). Lower amounts were present in June because the growing season was still in the early stages. The algaecide treatment was responsible for the sudden decline in chlorophyll a in mid-July. Levels remained low until September when they rose to near or above the previous highs. With no treatment, concentrations would have undoubtedly remained high throughout the summer.

As expected, Secchi disk readings (Fig. 4) generally fluctuated with chlorophyll a, declining (reduced light penetration) as chlorophyll a increased and increasing (greater light penetration) with reduced chlorophyll a.

Summer water temperatures were noticeably cooler in the deeper waters, declining from 23 or 24°C (73 or 75°F) in the first two meters (6.5 ft) to around 11°C (52°F) at the bottom (Fig. 5). More significant, however, was the rapid decrease in dissolved oxygen from greater than 5 mg/l (the level required to support desirable species of fish such as trout) in the upper two meters (6.5 ft) to very low levels in the lower four meters (13 ft) (Fig. 5). Under such conditions, fish must use the warmer upper layers to obtain adequate oxygen. Here, rough fish such as suckers have a competitive advantage over trout. This eventually results in a decline in trout and a predominance of rough fish. Thus, a thriving trout population would not be expected in Greenhill Lake.

The decrease in dissolved oxygen probably occurred when algae cells which must grow near the surface to obtain adequate light, began to die and sink to the deeper water. As the cells decomposed, oxygen was utilized, and concentrations declined. The further reduction of dissolved oxygen between July 16 and August 15 would be expected as the process continued, but may have been intensified by the die-off of algae after the mid-July control treatment.

Fecal coliform bacteria remained well below the 2,000/liter limit for body contact recreation throughout the sampling period. Bacteria counts at Station 1 were somewhat higher than those in the rest of the lake **(Fig. 6)**. Low values at the inshore stations indicated no direct pollution from cottages. This, however, does not entirely eliminate the possibility that some sub-surface seepage was taking place as bacteria counts would not normally detect this.

As mentioned, it was speculated that natural causes and faulty sewage systems were responsible for the lake's problem. The survey data, however, showed phosphorus levels at the inlet (Station 1) to be much higher than in the remainder of the lake **(Fig. 2)** indicating that the source of the problem was on the inlet stream. Further investigation on October 9th, 1985 revealed a piggery about two kilometers (1.2 miles) upstream of the lake. A waste storage lagoon was present but not operable as liquid was flowing directly through it and across a field and wooded area to the inlet stream. Sludge deposits were observed in the field and in the woods along the stream.

Water samples collected on the same day showed the following results:

STATION	TOTAL PHOSPHORUS (mg/l)
Inlet stream at Staples Settlement Road	less than 0.01
Piggery effluent 5 meters above confluence with stream	approx. 13.5
Stream at confluence with effluent	0.28
Stream 50 meters below confluence with effluent	0.47

It was thus concluded that the piggery was the major source of the nutrients causing the algal blooms in Greenhill Lake. This also explained the somewhat higher bacteria levels at the lake's inlet. Piggery waste is high in fecal coliform bacteria but the organisms have rapid die-off rates. Die-off plus a certain amount of dilution in the stream would have reduced bacteria counts by the time waste reached the mouth of the stream, but sufficient numbers remained to keep counts somewhat higher than those in the remainder of the lake.

Upon becoming aware of the situation, Environment New Brunswick staff required repair of the lagoon and removal of sludge deposited on open land. Unfortunately, access problems in the wooded area made sludge removal there impracticable.

Recommendations

Control of the piggery waste should permit the lake to improve, but information on hand is not sufficient to predict when acceptable conditions for recreation and fisheries will be achieved. The phosphorus laden material in the woods may migrate to the lake and contribute to the algal problem for some time. In addition, phosphorus which is already in the lake and incorporated in the bottom sediments will be periodically released to promote algal growth. A portion will be returned to the bottom as algae die and decompose, only to be available for future recycling. While these factors will tend to retard lake recovery, the lake's relatively high flushing rate should enhance phosphorus export via the outlet and will tend to accelerate recovery.

In the absence of a sound information to predict when and at what rate natural improvement will occur, it is difficult to recommend a specific management plan for Greenhill Lake. Several options are available and should be carefully considered in determining which is most desirable. Studies to define phosphorus movements and cycling in the system will be essential to making a sound decision.

Management options and some of their possible advantages and disadvantages are listed below:

(1) Allow the lake to cleanse naturally. No outlay of cash would be necessary but the recovery time could be unacceptable. Fisheries and recreation would continue to be impaired for a period of time.

(2) Treat with an algaecide while natural improvement takes place. Recreational values would be improved and maintained, but dissolved oxygen levels may not be

sufficient to support trout for some time. The cost would vary dramatically depending on the product used. Government approval to apply an algaecide would be required.

This option offers a number of advantages in that:

a) control of algal growth may promote phosphorus export,

b) a reasonable level of recreational quality would be achieved in a short time, and

c) additional time would be available to complete studies of phosphorus dynamics to better indicate what further action, if any, would be necessary.

(3) Remove the phosphorus enriched material along the inlet stream. This may hasten recovery of the lake but costs could be high. Phosphorus release rates would have to be measured as part of the aforementioned studies to evaluate the cost effectiveness of this measure.

(4) Treat the lake with chemicals to inactivate phosphorus. This was successful in Annabessacook Lake, Maine where aluminum compounds were utilized (costs unknown), but phosphorus inputs were first brought under control. Effectiveness could thus depend on measures taken along the inlet stream. The feasibility of some form of chemical treatment here might also be considered.

(5) Dredge sediments from the lake bottom. Costs could be prohibitive and spoil disposal could present environmental problems. Control of the inlet area may again be necessary.

At the current state of knowledge, and in the interest of avoiding unnecessary or excessive expenditures of money, it appears that option (2) would be the most favourable way to proceed at this time. Other options may then be further considered as necessary.

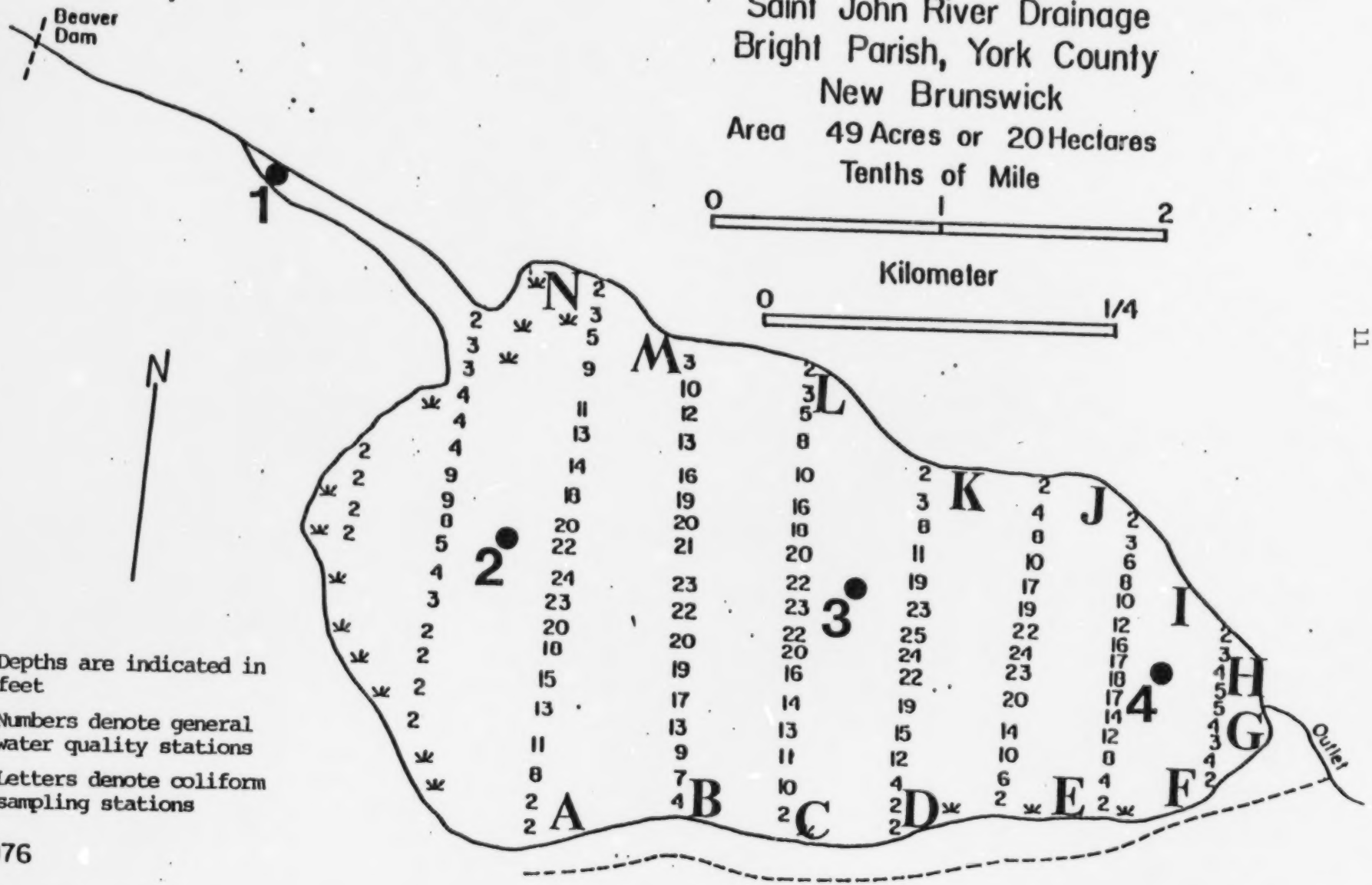
In the meantime,inputs of phosphorus to the lake should be minimized where feasible. The piggery should be monitored regularly to ensure that no waste is released to the watershed of Greenhill Lake. Cottage owners and permanent residents should ensure that their sewage disposal systems are operating properly. Use of fertilizers on fields, lawns, or gardens should be avoided, and any detergents used should be the low phosphate variety. Any future development around the lake or on its watershed should be carefully controlled to prevent any further nutrient loading to the lake.

FIG. 1

GREENHILL LAKE

Saint John River Drainage
Bright Parish, York County
New Brunswick

Area 49 Acres or 20 Hectares



Depths are indicated in feet

Numbers denote general water quality stations

Letters denote coliform sampling stations

1976

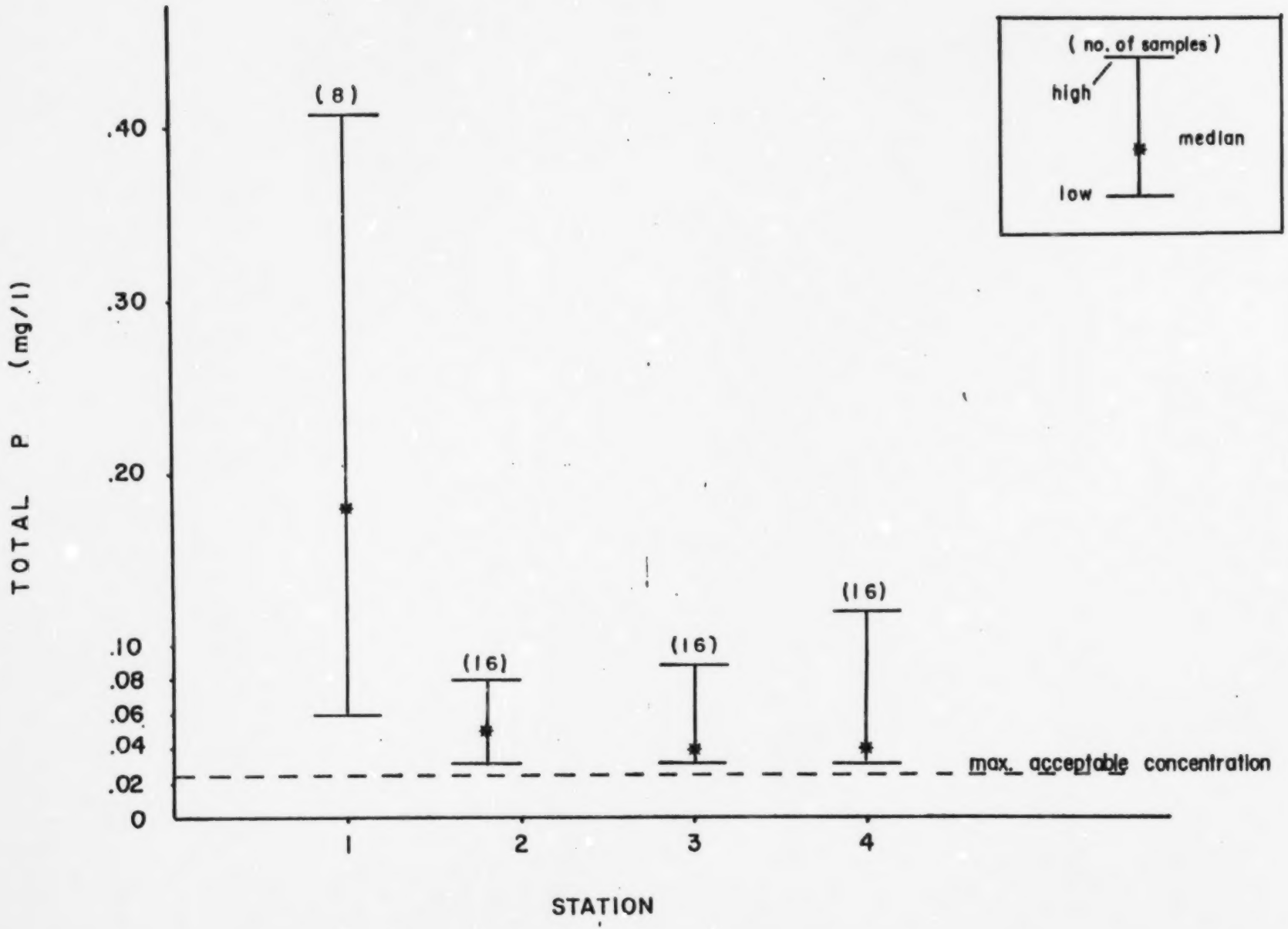


FIG. 2 PHOSPHORUS CONCENTRATIONS – Greenhill Lake – June – September 1985

FIG 3 - CHLOROPHYLL A CONCENTRATIONS, GREENHILL LAKE, JUNE - SEPT. 85.

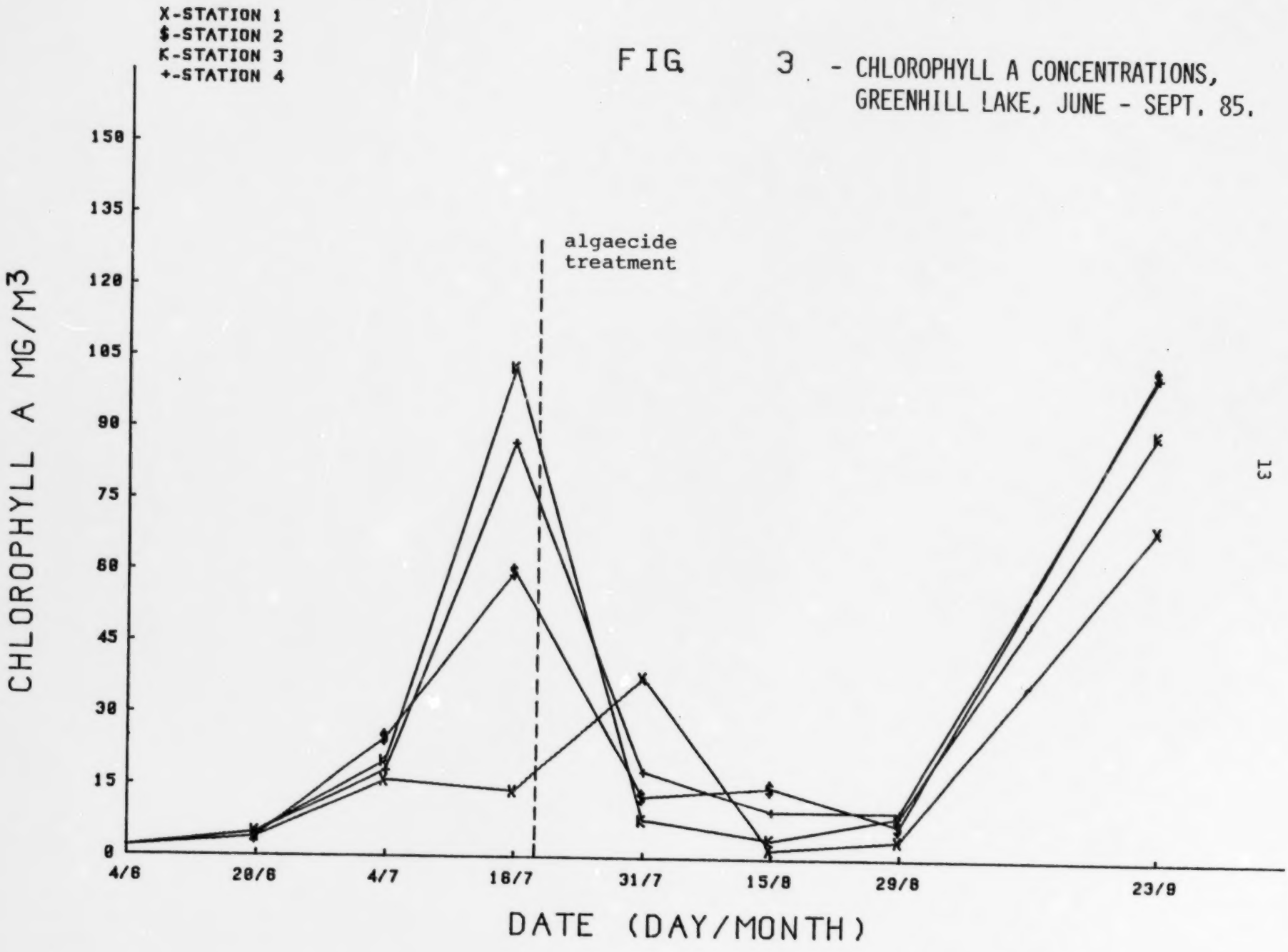
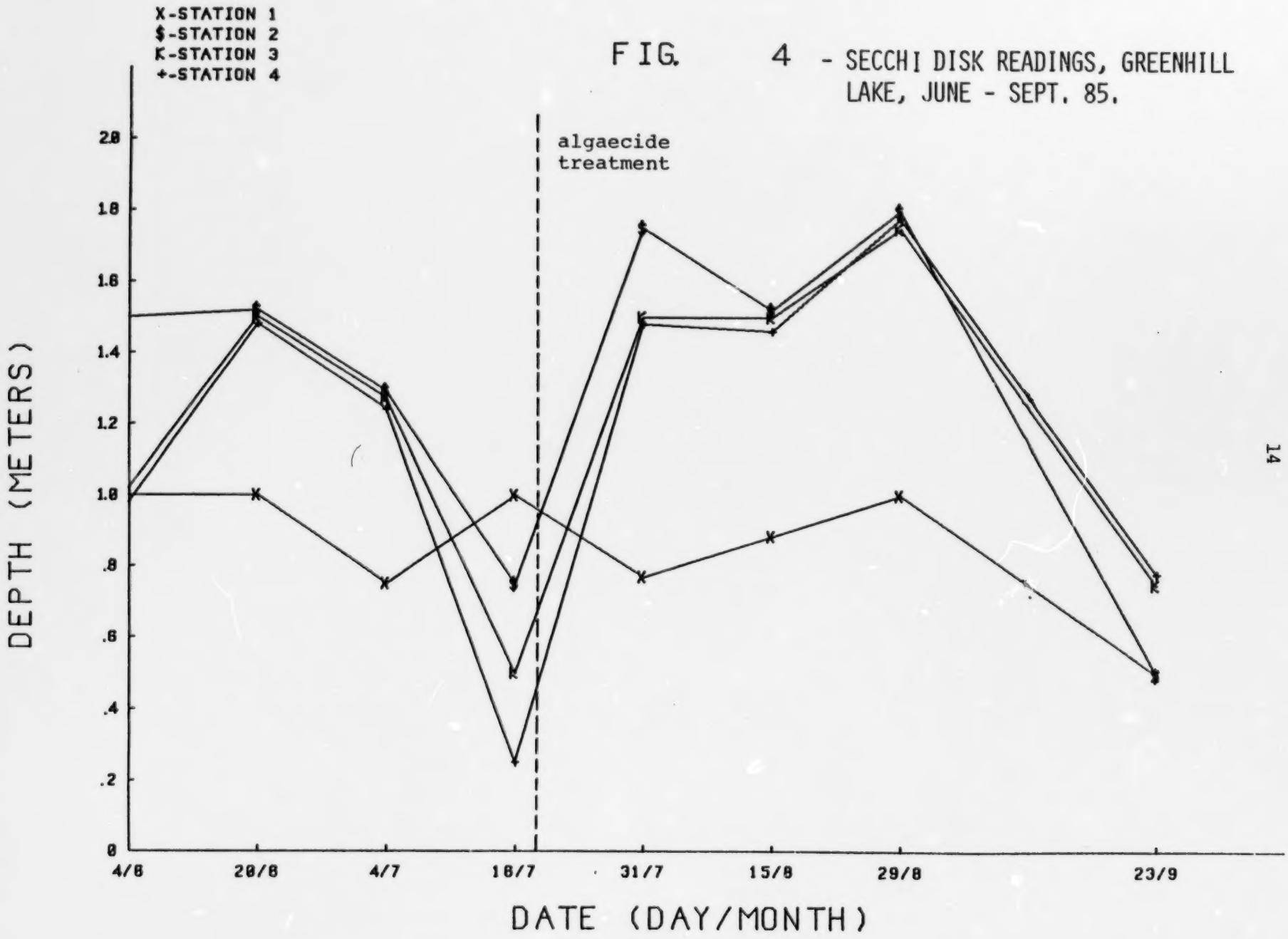


FIG. 4 - SECCHI DISK READINGS, GREENHILL LAKE, JUNE - SEPT. 85.



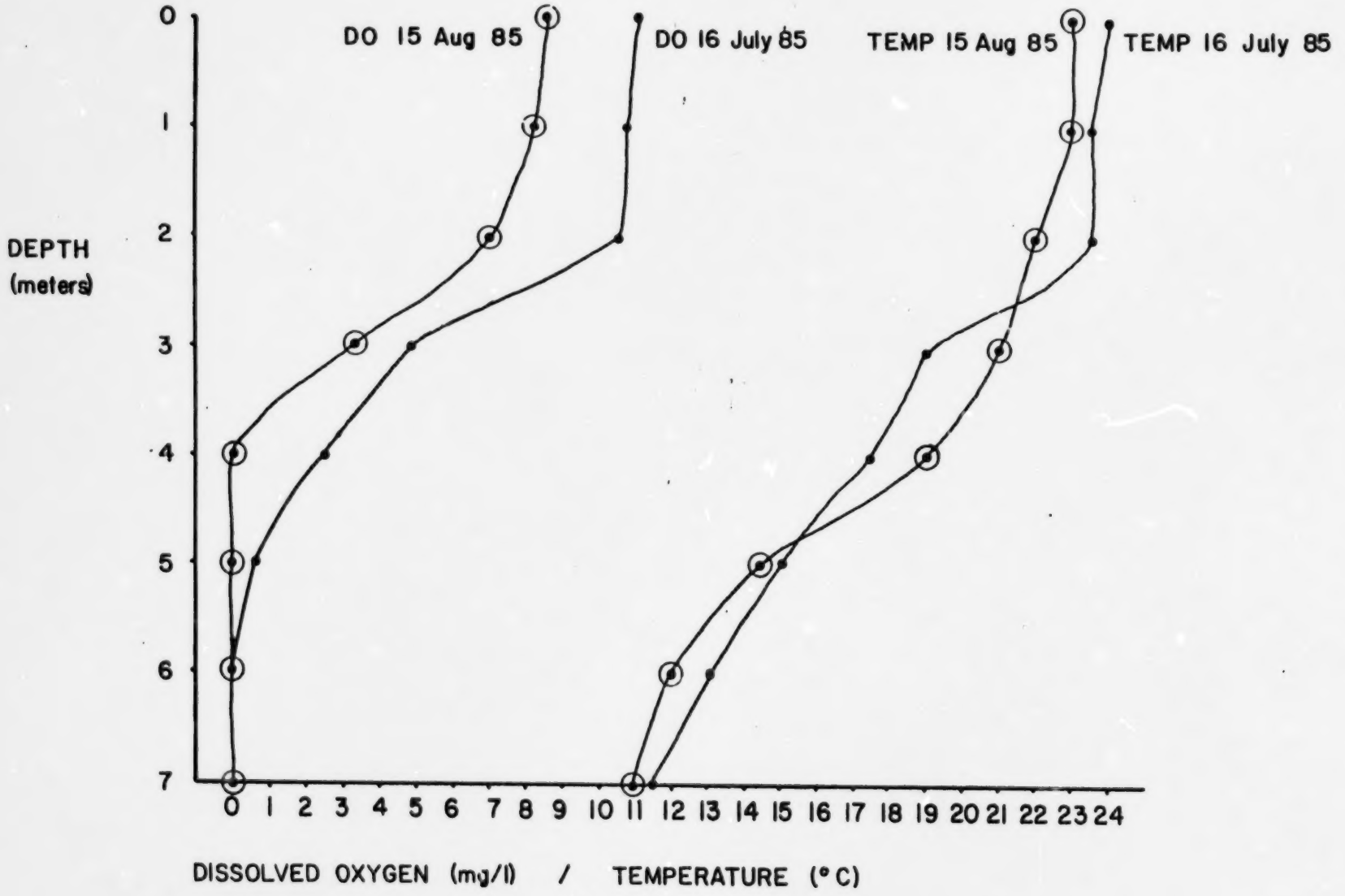


FIG. 5 Dissolved oxygen and temperature curves, Greenhill Lake, Station 3

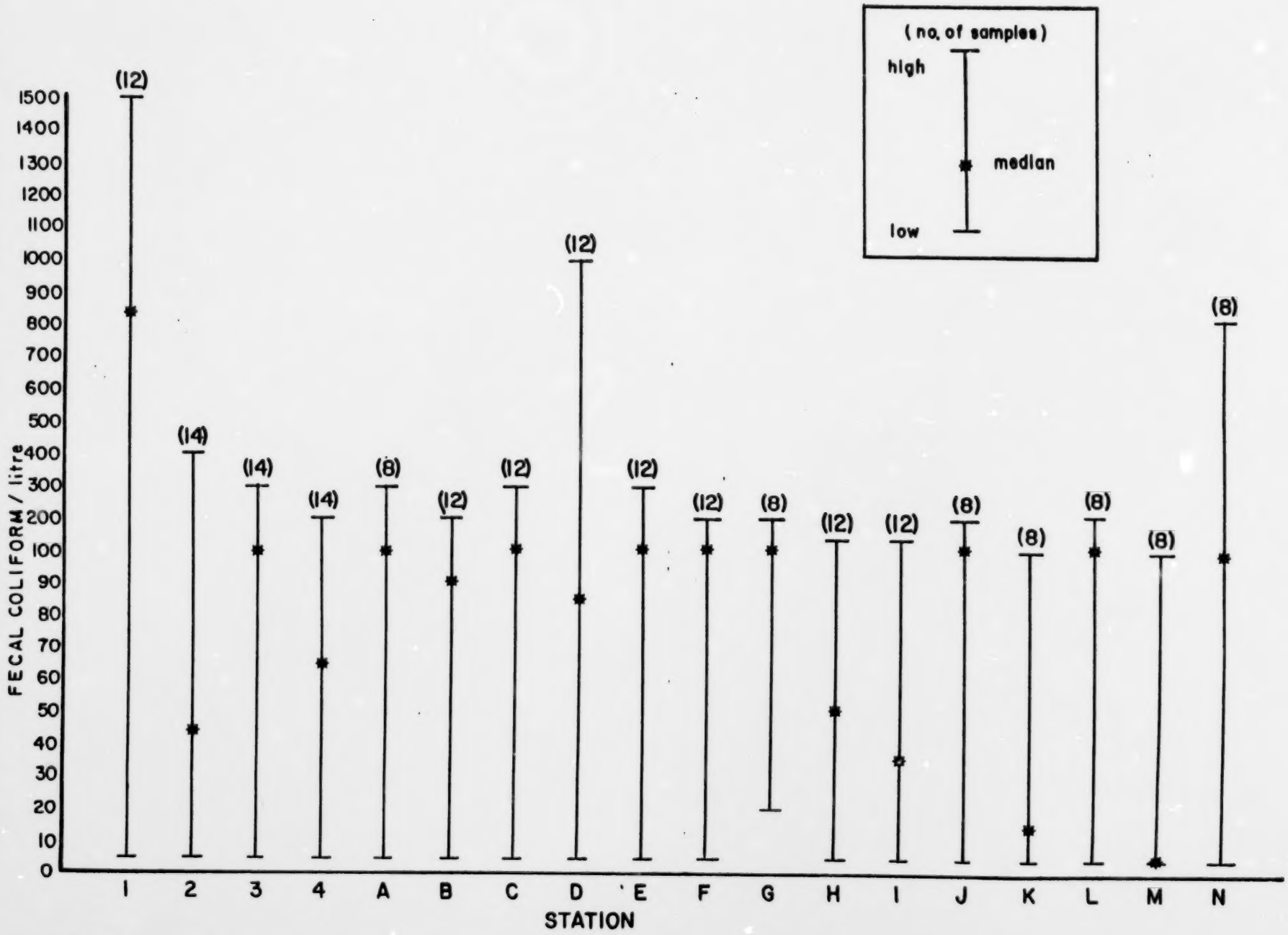


FIG. 6 FECAL COLIFORM BACTERIA CONCENTRATIONS - Greenhill Lake - June - September 1985